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Original Research Article

Determining the Inhibition Efficiency of Lasienthera Africanum (LA) as a Natural Corrosion Inhibitor on Aluminum and Mild steel in HCL Environment

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Abstract: Numerous failures and eventual losses in the oil and gas industry have been traced to corrosion processes. Failures resulting from the inability of metals to support designed load requirement because of losses imposed by corrosion effects and this can be combated economically through the use of chemical inhibitors despite the fact that synthetic inhibitors are effective, nonetheless they are associated with problems of toxicity disposal litigation and enormous cost. In order to protect the environment and reduce cost the use of green or natural inhibitors as substitute and partial replacement of chemical inhibitors have become a method of choice, however inhibitors are environment specific therefore necessitating for the need for deep research into metal-inhibitor-media combination that would produce the best result In this study natural inhibitor will be employed on mild steel and aluminum respectively in a hydrochloric environment. lasienthera africanum (LA) was adopted to be the natural inhibitor. For mild steel and aluminum specimen, these samples were sourced from chemical industries and workshops and were immersed in O.5M HCL solution in the absence and presence of varying inhibitor concentrations. For a period of 18 days. Weight Loss (WL) technique was adopted and WL data's were recorded for every 2 days for 18 days. WL experiment was perfonned and corrosion rate was calculated, out of which the highest inhibition efficiency LA of O.6g was (94.93%) for mild steel and *(99.56%)* for aluminum O.6g concentration of LA performed best for mild steel and aluminum immersed in HCL respectively. Thus the control of corrosion induced wastage of infrastructure through the use of natural inhibitor system could be use to mimic the exact corrosion process rather than costly experimentation are major contributions of this work.

Keywords: Inhibition Efficiency, Lasienthera Africanum.

INTRODUCTION

Corrosion is a serious problem in this modern age of technological advancement. This accounts for a lot of economic losses and irreversible structural damage. The cost of corrosion failures annually for any nation is difficult to estimate per annum, but it has been stated that the wastage of material resources by corrosion ranks third after war and disease (Olugbenga *et al.*2011). Efforts have been made to restrain the destructive effects of corrosion using several preventive measures (Loto *et al.* 1989, Popoola *et al.*2011 and Davis *et al*. 2001). The effects of corrosion in our daily lives can be direct by affecting the useful service lives of our possessions, and indirect, in that producers and suppliers of goods and services incur corrosion costs, which they pass on to consumers. At home, corrosion is readily recognized on automobile body panels, charcoal grills, outdoor furniture, and metal tools (Denny *et al*. 1996). The corrosion of steel reinforcing bars in concrete usually proceeds out of sight and suddenly results in failure of a section of bridges or buildings. Virtually all metals will corrode to some extent; the fossil—fuel boilers and fossil-fuel fired power generators equipment experience corrosion problems in such component as steam generator and water walls surrounding the furnace (Natarajanf & Sivan, 2003). Perhaps most dangerous of all is corrosion that occurs in major industrial plants, such as electrical power plants or chemical However, the consequences of corrosion are economic and could lead to: Replacement of corroded equipment; overdesign to allow for corrosion; preventive maintenance, for example, painting;

shutdown of equipment due to corrosion failure; fontamination of a product; loss of efficiency—such as when overdesign and corrosion products decrease the heat transfer rate in heat exchangers; loss of valuable product, for example, from a container that has corroded through; inability to use otherwise desirable materials; damage of equipment adjacent to that in which corrosion failure occurs.

Corrosion affects most of the industrial sector (Oil and Gas Industries) as it breaks down metals and may cost billions of dollars each year for prevention and replacement maintenance. The objective of this study is to determine the inhibition efficiency of Lasienthera africanum as a natural corrosion inhibitor on aluminum and mild steel in hydrochloric acid (HCL) environment**.** This study is of great importance as it deals with the right inhibitor to be used which is not toxic and poisonous to the environment when handling and also the type of inhibitor that's is cheap to acquire thereby cuttings cost for corrosion protection.

REVIEW OF LITERATURE

Corrosion may be defined as a destructive phenomenon, chemical or electrochemical, which can attack any metal or alloy through reaction by the surrounding environment and in extreme cases may cause structural failure. The corrosion occurs because of the natural tendency for most metals to return to their natural state (reverse of metallurgy); e.g., iron in the presence of moist air will revert to its natural state, iron oxide. Corrosion could be basically carried by water intrusion and some environmental factors. Water intrusion is the principal cause of corrosion problems encountered in the field use of equipment. Water can enter an enclosure by free entry, capillary action, or condensation. With these three modes of water entry acting and with the subsequent confinement of water, it is almost certain that any enclosure will be susceptible to water intrusion. At normal atmospheric temperatures the moisture in the air is enough to start corrosive action. Oxygen is essential for corrosion to occur in water at ambient temperatures. Other factors that affect the tendency of a metal to corrode are acidity or alkalinity of the conductive medium (pH factor), stability of the corrosion products, biological organisms (particularly anaerobic bacteria), Variation in composition of the corrosive medium and temperature. In nature, metals are not found in Free State due to their reactivity. Metals are generally in high energy state because some energy is added during their manufacturing process from the ores. Low energy - state ores are more stable than the high energy — state metals. As a result of this uphill thermodynamic struggle, the metals have a strong driving force to release energy and go back to their original form. Hence the metals revert to their parent state or ore under a suitable corrosive environment. The electrochemical process involved in corrosion by nature is opposite to the extractive metallurgy involved in manufacturing of the metals. The oxidation of a metal at an anode (a corroded end releasing electrons) and the reduction of a substance at a cathode (a protected end receiving electrons). In order for the reaction to occur, the following conditions must exist: Two areas on the structure must differ in electrical potential. Those areas called anodes and cathodes must be electrically interconnected. Those areas must be exposed to a common electrolyte. An electric path through the metal or between metals be available to permit electron flow. When these conditions exist, a corrosion cell is formed in which the cathode remains passive while the anode deteriorates by corrosion. As a result of this process, electric current flows through the interconnection between cathode and anode. The cathode area is protected from corrosion damage at the expense of the metal, which is consumed at the anode. The amount of metal lost is directly proportional to the flow of direct current. Mild steel is lost at approximately 20 pounds for each ampere flowing for a year. (Thomas, 1994). Corrosion processes are responsible for numerous losses mainly in the industrial scope. It is clear that the best way to combat it is prevention. **V** Among the various methods to avoid or prevent destruction or degradation of metal surface, the corrosion inhibitor is one of the best know methods of corrosion protection and one of the most useful on the industry. This method is following stand up due to low cost and practice method.

Important researches have being conducted with government investment mainly in large areas such as development construction of new pipelines for shale gas and growth in construction. The focus of these researches has being the inhibitors applications in water and concrete for the protection of metals. Historically, inhibitors had great acceptance in the industries due to excellent anti- corrosive proprieties. However, many showed up as a secondary effect, damage the environment. Thus the scientific community began searching for friendly environmentally inhibitors, like the organic inhibitors. This chapter presents a revision of the corrosion inhibitors applications mainly the novel compositions environmentally friendly. Is describes the mechanisms of action of inhibitors, main characteristics, environmental impact, technical analysis and calculation of efficiency.

DEVELOPMENT

The consequences of corrosion are many and the effect of these on the safe, reliable and efficient operation of equipment are often more serious than simple loss mass of a metal. Corrosion can be minimized by employing suitable strategies which retard the corrosion reaction. It is widely accepted that inhibitors especially the organic compounds can effectively protect the metal from corrosion. Several works have been done with compounds containing polar functions on the corrosion inhibition of metals in various aqueous media. Polymer functions as corrosion inhibitor because of their ability to form complexes through their functional group, with metal ions which occupy large area and by so doing blanket the metal surface from aggressive environment. The practice of corrosion inhibition in recent years has become oriented towards health and safety considerations. Consequently greater research efforts have been directed towards formulating environmentally acceptable organic compounds and polymers as corrosion inhibitors for metals is reviewed.

The use of inhibitor is one of the most dogmatic method employed to tackle corrosion especially in acidic media (Touir *et at*., 2008). Inhibitors naturally react physically or chemically with metals by adsorbing on its surface. The adsorption may form a layer on the metal and function as a barrier protecting the metal. The adsorption process, as reported by Emregul and Hayvali (2006), depends on the nature and surface charge of the metal, the chemical structure of the organic molecule, distribution of the charge in the molecule and the aggressive medium. The efficiency of inhibitor may depend on the nature of environment, nature of metal surface, electrochemical potential at the interface and the structural feature of inhibitor, which include number of adsorption centres in the molecule, their charge density, the molecular size and mode of adsorption (Ahamed *et al*., 2009). The adsorption phenomenon could take place via electrostatic attraction between the charged metal and charged inhibitors molecules and Pi Q— electron interaction with the metals (Abdel-Gaber *et al*., 2009). A good inhibitor should be easily prepared from low cost raw materials and the organic compound has to contain electronegative atoms such as 0, N, P. and S. Inhibition increases in the sequence: 0 < N < S < P. (Musa *et at*. . 2009). These organic compounds function by forming a protective adsorption layer on aluminum surface which isolates the corroding metal from action of corrodent. Organic compounds have been widely used as corrosion inhibitor for aluminum in acid media. Several inhibitors in use is either synthesized from cheap raw materials or chosen from compounds having heteroatoms in their aromatic or long chain carbon system. The influence of such organic compounds on the corrosion of aluminum in acidic solution has been investigated by several researchers (Ebenso, 2004; Khandelwal, 2010; Oguzie, 2004). The inhibition property of these compounds is attributed to their molecular structure (Mora-Mendoza *et al*., 2002). The organic inhibitors decrease corrosion rate by adsorbing on the metal surface and blocking the active sites by displacing water molecules and form a compact barrier film on the metal surface. In recent years, natural products such as plant extracts have become important as an environmentally acceptable, readily available and renewable source of materials for wide range of corrosion control. Attention has been focused on the corrosion inhibiting properties of plant extracts because plant extracts serve as incredibly rich sources of naturally synthesized chemical compounds that are environmentally benign, inexpensive, readily available and renewable sources of materials and can be extracted by simple procedures. A lot of works have been reported on the inhibition of acid corrosion of metals using economic plants such as Vernonia Amydalina (bitter leaf) extracts (Loto, 1998), Zenthoxylum alatum plant (Chauhara and Gunasekara, 2006), the juice of Cocos nucifera (Abiola *et al*., 2002), Fenugreek (Ehteram, 2007), seeds extract of Strychnos nuxvomica (Ambrish Singh *et al*, 2010), Gossipium hirsutum Liquid extract (Abiola *et al*., 2009), Areca catechu (Vinod Kumar *et a*!, 2011).

2.2.2 Mechanisms of Actions of Inhibitors

Inhibitors are substances or mixtures that in low concentration and in aggressive environment inhibit, prevent or minimize the corrosion. 2014 Dariva and Galio; licensee in Tech. This is a paper distributed under the terms of the Creative. Commons Attribution License http://creativecommons.org/1icenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Generally the mechanism of the inhibitor is one or more of three that are cited.The inhibitor is chemically adsorbed (chemisorption) on the surface of the metal and forms a protective thin film with inhibitor effect or by combination between inhibitor ions and metallic surface; the inhibitor leads a formation of a film by oxide protection of the base metal; the inhibitor reacts with a potential corrosive component present in aqueous media and the product is a complex.

2.2.3 Inhibitors Classifications

The corrosion inhibitors can be chemicals either synthetic yr natural and could be classified by: The chemical nature as organic or inorganic; mechanism of action as anodic, cathodic or a anodic-cathodic mix and by adsorption action, or; as oxidants or not oxidants. In general, the inorganic inhibitors have cathodic actions or anodic. The organics inhibitors have both actions, cathodic and anodic and the protective by a film adsorption.

2.2.4 Inorganic inhibitors *Anodic inhibitors*

Anodic inhibitors (also called passivation inhibitors) act by a reducing anodic reaction, that is, blocks the anode reaction and supports the natural reaction of passivation metal surface, also, due to the forming a film adsorbed on the metal. In general, the inhibitors react with the corrosion product, initially formed, resulting in a cohesive and insoluble film on the metal surface. Figure 2 shows a potentiostatic polarization diagram of a solution with behavior inhibitor anodic. The anodic reaction is affected by the corrosion inhibitors and the corrosion potential of the metal is shifted to more positive values. As well, the value of the current in the curve decreases with the presence of the corrosion inhibitor (Royal 2005). The anodic inhibitors reacts with metallic ions Men+ produced on the anode, forming generally, insoluble hydroxides which are deposited on the metal surface as insoluble film and impermeable to metallic ion. From the hydrolysis of inhibitors results in OH- ions. Figure 3 shows how the mechanism of the anodic inhibitory effect is (Ambrish 2002). When the concentrations of inhibitor becomes high enough, the cathodic current density at the primary passivation potential becomes higher than the critical anodic current density, that is, shift the potential for a noble sense, and, consequently, the metal is passivated. For the anodic inhibitors effect, it is very important that the inhibitor concentrations should he high enough in the solution. The inappropriate amount of the inhibitors affects the formation of film protection, because it will not cover the metal completely, leaving sites of the metal exposed, thus causing a localized corrosion. Concentrations below to the critical value are worse than without inhibitors at all. In general can cause pitting, due reduction at the anodic area relative to cathodic, or can accelerate corrosion, like generalized corrosion, due to full breakdown the passivity. Some examples of anodic inorganic inhibitors are nitrates, molybdates, sodium chromates, phosphates, hydroxides and silicates.

2.2.5 Techniques for Analysis of Inhibitors

The most usefully technique to analysis the effectiveness of an inhibitor are weight loss experiment and electrochemical measurements, like polarization curve method and the impedance measurement analyzing. In addition, microscopy techniques are used to characterize the corrosion process.

2.2.6 Considerations to employ inhibitors

For all types of inhibitors, we should consider some environmental actions actors because some elements such as metals, p1-I, composition, impurities, agitation, temperature, geometry of the system, the concentration of inhibitor and the mixture of one or more inhibitors may change the anti-corrosive mechanism.

2.2.7 Inhibitor efficiency

The inhibitor efficiency could be measured by the follow equation:

$$E_f = \frac{R_i - R_o}{R_c} \; x \; 100 \qquad (2.1)$$

where,
E*f* is inhibitor efficiency (percentage),
Ri is corrosion rate of metal with inhibitor and
Ro is corrosion rate of metal without inhibitor.

2.3 BASIC APPLICABLE PRINCIPLE

Metallic structures can be protected from corrosion in many ways. A common method involves the application of protective coatings made from paints, plastics or films of noble metals on the structure itself (e.g., the coating on tin cans). These coatings form an impervious barrier between the metal and the oxidant but are only effective when the coating completely covers the structure. Flaws in the coating have been found to produce accelerated corrosion of the metal.

2.3.1 Cathodic Protection

Cathodic protection using an impressed current derived from an external power supply is a related form of protection in which the metal is forced to be the cathode in an electrochemical cell. For example, most cars now use the negative terminal on their batteries as the ground. Besides being a convenient way to carry electricity, this process shifts the electrical potential of the chassis of the car, thereby reducing (somewhat) its tendency to rust.

Corrosion inhibitors can be added to solutions in contact with metals (e.g. inhibitors are required in the antifreeze solution in automobile cooling systems). These compounds can prevent either the anode or the cathode reaction of corrosion cells; one way that they can do this is by forming insoluble films over the anode or cathode sites of the cell. Examples of anodic inhibitors are sodium phosphate or sodium carbonate while zinc sulfate and calcium or magnesium salts act as cathodic inhibitors. New forms of paints are being developed which take advantage of similar properties. These paints promise to nearly eliminate corrosion in applications like painted car fenders, etc.

2.4 BASIC APPLICABLE MATERIALS

2.4.1 Aluminum as a Structural Metal

Aluminum is a silvery white material and a member of boron group. It is the most abundant metal in the crust, and the third most abundant element therein, after oxygen and silicon. It is soft, durable, lightweight, malleable metal with appearance ranging from silvery to dull grey, depending on the surface roughness. Aluminum is nonmagnetic and non-sparking. It is also insoluble in alcohol, though it can be soluble in water in certain forms. The yield strength of pure aluminum is 7-11 MPa, while aluminum alloys have yield strengths ranging from 200 MPa to 600 MPa (Toraif, 1999). Aluminum has about one-third the density and stiffness of steel. It is ductile, and easily machined, cast, drawn and extruded. Corrosion resistance can be excellent due to a thin surface layer of aluminum oxide that forms when the metal is exposed to air, effectively preventing further oxidation. The strongest aluminum alloys are less corrosion resistant due to galvanic reactions with alloyed copper (Das *et al*. 2004).

This corrosion resistance is also often greatly reduced when many aqueous salts are present, particularly in the presence of dissimilar metals. Aluminum is the most widely used non-ferrous metal (Cock *et al.*, 1999). Having its global production in 2005 as 31.9 million tonnes, It exceeded that of any other metal except iron which was (837.5 million tonnes) (Hethorington *et al.,* 2007). Relatively pure aluminum is encountered only when corrosion resistance and/or workability is more important than strength or hardness. A thin layer of aluminum can be deposited onto a flat surface by physical vapour deposition or (very infrequently) chemical vapour deposition or other chemical means to form optical coatings and mirrors. When so deposited, a fresh, pure aluminum film serves as a good reflector of visible light and an excellent reflector of medium and far infrared radiation. Pure aluminum has a low tensile strength, but when combined with thermo-mechanical processing, aluminum alloys display a marked improvement in mechanical properties, especially when tempered. Aluminum alloys form vital components of aircraft and rockets as a result of their high strength-to-weight ratio. Aluminum readily forms alloys with many elements such as copper, zinc, magnesium, manganese and silicon (e.g., duralumin). Today, almost all bulk metal materials that are referred to as “aluminum”, are actually alloys. For example, the common aluminum foils are alloys of 92% to 99% aluminum. (Millberg, 2010). Aluminum metal and alloys are used in Transportation (automobiles, aircraft, trucks, railway cars, marine vessels, bicycles etc.) as sheet, tube, castings etc. Packaging (cans, foil, etc.), Construction (windows, doors, siding, building wire, etc.) other uses include household items, from cooking utensils to baseball bats, watches. Street lighting poles, sailing ship masts, walking poles etc. Outer shells of consumer electronics, and also cases for equipment such as photographic equipment. Electrical transmission lines for power distribution MKM steel and Alnico magnets are all components made from aluminum metal. Super purity aluminum (SPA, 99.980% to 99.999% Al), are used in electronics and CDs. Heat sinks for electronic appliances such as transistors and CPUs. Substrate material of metal-core copper clad laminates used in high brightness LED lighting. Powdered aluminum is used in paint, and in pyrotechnics such as solid rocket fuels and thermite.

2.4.2 LasieiitIiera africanuin (Editan Leaf)

Lasienthera africanum is a low erect or subscandent, vigorous shrub with stout recurved prickles and a strong odour of black currents; *Lasienth era africanum* has several uses, mainly as an herbal medicine and Plant extracts are used in folk medicine for the treatment of cancers, chicken pox, measles, asthma, ulcers, swellings, eczema, tumours, high blood pressure, bilious fevers, catarrhal infections, tetanus, rheumatism and malaria of abdominal viscera (Mahathi S. 2012). *Lasienthera africanum* is found mainly in the humid tropical forest regions of Central African Republic, Cameroon, Gabon, Democratic Republic of the Congo and Angola. In Nigeria, it is mostly found in the southern part of the country (Calabar and Akwa Iborn) and used in preparing special delicacies (editan soup). In this research, there is a shift from the normal medicinal activities of Lasienthera africanum to other function like corrosion inhibitor.

3. MATERIALS AND METHOD

3.1. Material Preparation –

The metals used for the study are mild steel and aluminum alloy. Mild steel was used because of its versatility as material of construction. It is used widely in the construction industry because of its availability and strength. It finds wide spread application in the utilities, food, chemical and petrochemical industries even though it is easily affected by the aggressive environment. Because of its strength it is used for load bearing applications like the shell of a pressure vessel or the rotating shaft of a machine. The replacement of mild steel parts is six times cheaper when compared to stainless steel. In the case of Aluminum and its alloys they are utilized principally in light weight applications. They also offer some form of CO1TOSIOn resistance because of their affinity for oxygen to form a passive oxide layer. They are used mostly as component parts in valves, pumps, actuators. However, when these metals are exposed to some aggressive media they become vulnerable as they experience metal losses which ultimately lead to reduction in their effective sizes, thickness or diameter. This means the machine part will be unable to support tensile, compressive, torsion or axial loads as the case may be and failure might ensue. However, the option of prolonging the life of the metal before eventually replacing it offers a cost effective solution by putting more money in the hand of a manufacturer. The use of inhibitors is a viable option which was investigated in this study.

3.1.1 Chemical Composition of the Metals

The metals were sourced from Granges Nigeria Limited, an indigenous storage tank fabrication and rehabilitation company involved in the revamping of crude oil tank 301-TK at the Warn Refining and Petrochemical Company and Welding and Offshore Technology Department at Petroleum Training Institute. It was subsequently subjected to chemical composition test at the University of Lagos Metallurgy and Materials Engineering Department by making use of an Optical

3.1.2 Metal Preparation for the Experiment

In order to conduct the weight loss experiment the metals were cut into 3cm by 2cm sizes or dimension using the guillotine. They were then subjected to chemical treatments. The mild steel sample was degreased by immersion in benzene and then dried. It was then immersed in a solution of HC1 with acid to water ratio of 1 to 4 for 30 minutes at room temperature. They were then dried with clean cloth and stored in a desiccators. On the other hand, the aluminum samples were degreased with benzene and then dried before being immersed in nitric acid for 3 minutes at room temperature. After they were removed from the acid, they were rinsed with distilled water twice. Finally they were stored in desiccators prior to the commencement of the experiment.

Table-1: Elemental composition of mild steel employed for the study of the experiment

S/No	Metal	% Elemental Composition
I	Fe	98.89
2	C	0.1203
3	Si	0.0547
4	Mn	0.2654
5	P	<0.008
6	S	0.034
7	Cr	0.0528
8	Ni	0.2212
9	Mo	0.361
10	Cu	0.492
11	Al	0.0227
12	Ti	<0.000
13	V	0.011
14	Co	0.0313
15	Nb	0.0553
16	W	<0.042
17	Sn	<0.003

Table-2: Chemical composition of aluminum alloy employed for the study of the experiment

S/No	Metal	% Elemental Composition
I	Ai	98.89
2	Si	0.1487
3	Fe	0.3972
4	Cu	<0.007
5	Mn	0.0618
6	Mg	0.0462
7	Zn	0.000
8	Cr	0.178
9	Ni	<0.000
10	Ti	0.0115
11	Sr	<0.000
12	Zr	<0.000
13	V	0.0195
14	Ca	<0.000
15	Be	<0.000

3.1.3 Commercial Chemicals Utilized for the Study

All chemicals utilized in this research were of commercially pure and analytical grade quality. The chemicals utilized include: Isopropyl alcohol has a molecular formula of $(CH_3)_2$ CHOH with boiling point and density of 82°C and 0.785 g/mL respectively. It is a colourless liquid with slight alcohol odour. It was obtained from Kerrnel and used for treating mild steel and aluminum samples; Hydrochloric Acid (HC1) fumes strongly in moist air and is soluble in water with resultant heat evolution. It has a density and boiling point of 1.2 g/mL and 57°C respectively. It is air and light sensitive and it was obtained from Sigma Aldrich® and used for treating the mild steel sample to completely remove the rust; Silica Gel (Blue) used as an active drying and absorption agent for moisture during the storage of the samples in the desiccators. Its high specific surface area (800m2/g) makes swift moisture adsorption possible (Christy, 2012). It was obtained from Burgoyne Burbidges and Co (India) and placed in the desiccators. It has a bulk density, melting and boiling point of 570-700 gIL, 1610 and 2230°C respectively; Benzene is an aromatic organic compound with molecular formula of C_6H_6 and density of 0.879 gImL. It is a clear, colorless, highly flammable liquid with a pronounced characteristic odour and a boiling point of 80°C. It has a purity of 99% and was obtained from Qualikerns and used for degreasing the mild steel and aluminum alloy sample; Nitric acid (11N03) is an oxidizing agent and it was obtained from Scharlau®. It is a clear colourless liquid with a boiling point of 120.50C and purity of 65%. It has a density of 1.41 g/rnL and it was used for treating aluminium alloy sample.

3.1.4 Media or Environment:

The environment utilized in this study is hydrochloric acid HCI. HC1 has been described earlier under the metals treatment section. The concentration of the HC1 used in this study was 0.5 and is colourless & odourless. It is hygroscopic and corrosive in nature and was obtained from Sigma Aldrich and used as the environment for the experimental study at a concentration of 0.5 M.

3.1.5 Natural **inhibitor Utilized for the Study**

Extracts of a plant was employed for the study. This is Lasienthera africanum (Editan Leaf) *Lasienthera africanum* is a low erect or subscandent, vigorous shrub with stout recurved prickles and a strong odour of black currents; Lasienthera africanum has several uses, mainly as an herbal medicine and Plant extracts are used in folk medicine for the treatment of cancers, chicken pox, measles, asthma, ulcers, swellings, eczema, turnouts, high blood pressure, bilious fevers, catarrhal infections, tetanus, rheumatism and malaria of abdominal viscera (Mahathi S. 2012). Lasienthera africanum is found mainly in the humid tropical forest regions of Central African Republic, Cameroon, Gabon, Democratic Republic of the Congo and Angola. In Nigeria, it is mostly found in the southern part of the country (Calabar and Akwa Thom) and used in preparing special delicacies (editan soup). In this research, there is a shift from the normal medicinal activities of Lasienthera africanum to other function like corrosion inhibitor

3.1.6 Preparation of Plant Extract for Corrosion Inhibition Studies

Lasienthera Africanum leaf sample was bought from Effurun market in Delta state Nigeria and was properly washed In order to prepare the extract, leafs were obtained in their fresh forms and subjected to drying under aerated or ventilated cover. This was done to make sure that the natural constituent of the leaves were not denatured. The dried leaves still maintained their “greenness” after drying. The leaves were pulverized using a grinding machine to obtain a very fine powder. In order to prepare the extract, Lasienthera Africanum were obtained in their fresh forms and subjected to drying under aerated or ventilated cover. This was done to make sure that the natural constituent of the leaves were not denatured. The dried leaves still maintained their “greenness” after drying. The leaves were pulverized using a grinding machine to obtain a very fine powder. This was then placed in a filter paper thimble and put into a compartment of the Soxhlet extractor, furnished with a condenser that was stationed on a distillation flask containing ethanol as extraction solvent (Harneurlaine et al., 2010). The acidic leaf extract was prepared by adding *5.Og* of the plant sample in 100ml 0.5M HCI The resulting solution was boiled for 3 hours and allowed to stand before filtering. It was observed that 0.l541g and 0.2528g of organic soluble matter dissolved in the acidic medium respectively. This becomes the stock solution and from these concentrations of O.3g and O.6g were made.

3.2 APPARATUS PREPARATION

3.2.1 Set up for Weight loss Experiment

The conventional weight loss method involves the weighing of the sample before immersion and then re-weighing after duration of pre-determined period. Afterwards same sample is re-immersed for the next duration. For example if the experiment is to run at 2 day interval for 18 days, it means every two days sample is removed, reweighed and re-immersed until the 18th day period. The removal and re-Immersion disrupts the metal-inhibitor interaction and may make the capture of the corrosion indices impossible. However, in this study we introduced an innovation by setting up Weight loss experiment for each interval. Metals were only removed for final reweighing at the end of the experimental period. This way it was possible to capture the exact metal-inhibitor interaction. Pretreated metal coupons measuring 2cm by 2cm were weighed and subsequently immersed in the test media consisting of varying concentrations of the natural inhibitor and control solutions *(0.5* M HC1 and inhibitor). After the duration, the samples were removed from the test media and reweighed and subsequently returned into the desiccators. The Weight loss experiment was conducted in accordance to standard procedure. To obtain the Weight loss, the mass obtained after the experiment was subtracted from the mass before the experiment. After obtaining the Weight loss data, it was possible to determine the corrosion rate and inhibitor efficiency.

3.3 TESTING

3.3.1 Weight Loss Measurement

This work involved the introduction of already prepared concentrations of the inhibitor into separate beakers maintained at room temperature. A total of seven beakers labeled (A-C) were used; with B and C, containing O.3g and O.6g of the acidic extract solution while A were used as the blank (control) for the experiment. The beakers labeled B AND C contains different volumes of stock solution of the inhibitor with concentrations of 0.3g and 0.6g which was made up to l00l each into different concentration of the acid 0.5M HCI in separate experiments. Previously weighed aluminum coupons and mild steel were then placed in the test solution. Each coupon was retrieved from the test solutions progressively for 1 hour in total of *5* hours. After the immersion test, the specimens were carefully dip in water and then properly cleaned to remove loose segments of the film of the corroded samples following by degreasing in ethanol and drying with acetone. The difference weight of the coupons was again taken as the weight loss. From the initial weight the aluminum and Mild steel, the weight loss, the corrosion rate (CR) (gcm2 /hr) and inhibition efficiency

Table-3: Inhibitor concentration of mild steel and aluminum for a period of 1 8days two day interval

S/N	inhibitor Concentration	Media	Metal	Immersion time (18 days)
1	0.3 LA	*0.5* M **HC1**	MS or Al	mass data was taken every 2 days for 18 days
2	0.6 LA	*0.5* M HC1	. MS or Al	mass data was taken every 2 days for 18 days

3.3.2 The Weight Loss

The weight loss is evaluated by the equation stated below

WL = CR x AT (3.1)

Where:
CR = Corrosion Rate
A = Area of the Aluminum and Mild steel (cm)
T = Time of immersion (hours)

3.3.3 The Corrosion Rate

Corrosion rate is evaluated by equation 3.2 as stated below

$$\text{Corrosion rate (CR)} \quad \frac{87.6W}{AxDxT} \qquad (3.2)$$

Where:
T = Immersion time in hours
W = weight loss in grams
A = Area of sample in square cm (cm^2)
D = Density of metal in g per cm^3

3.3.4 The inhibitor Efficiency

The inhibitor efficiency based on mass data (IE%) was obtained from the relationship in Equation *3.5* and as described by (Ebenso *et al*!., 2004; Omotosho *et al*., 2012a; Omotosho *et al*., 2012b and Omotosho *et al*., 2012c)

$$\text{Mass Based Inhibition Efficiency } (IEM\%) \quad \frac{CRcont - CRinh}{CRcont} \text{ (100) - (3.3)}$$

Where:
CRcont = Corrosion rate of sample in acid media (HCI) and
CRinh = Corrosion rate of metal sample in the presence of the inhibitor and the acid

3.4 DATA COLLECTION

Data Collected for Mild Steel in the Presence and Absence of Lasienthera Africanum

Table-3.4: Mild steel coupon weight before experiment was carried on

Sample Mild steel	Length	Breadth	Thickness	Weight
A	**3.08**	**2.46**	**0.2**	**10.316**
B	3.82	2.49	**0.2**	**12.881**
C	3.78	2.46	0.2	12.4 **70**

Table-3.5: Mild steel coupon weight after 2 days in *0.5* M HCI at 30°C containing 0.3 and 0.6g *Lasientheraafrjcanttrn* extract

Sample Mild steel	Inhibitor used	Weight
A	**CONTROL**	**10.200**
B	0.3 GRAM	12.799
C	0.6 GRAM	12.464

Table-3.6: Mild steel coupon weight after 4 days in 0.5 M HC1 at 30°C containing 0.3 and 0.6g *Lasienrheraafricanum* extract

Sample Mild steel	Inhibitor used	Weight
A	**CONTROL**	**10.130**
B	0.3 GRAM	12.764
C	0.6 GRAM	12.312

Table-3.7: Mild steel coupon weight after 6 days in 0.5 M HCI at 30°C containing 0.3 and 0.6g *Lasien theraafricanum* extract

Sample Mild steel	Inhibitor used	Weight
A	CONTROL	10.093
B	0.3 GRAM	12.747
C	0.6 GRAM	12.312

Table-3.8: Mild steel coupon weight after 8 days in 0.5 M HCI at 30°C containing 0.3 and 0.6g *Lasienth eraafricanum* extract

Sample Mild steel	Inhibitor used	Weight
A	CONTROL	10.071
B	0.3 GRAM	12.734
C	0.6 GRAM	12.250

Table-3.9: Mild steel coupon weight after 10 days in *0.5* M HC1 at 30°C containing 0.3 and 0.6g *Lasientheraafricanum* extract

Sample Mild steel	Inhibitor used	Weight
A	CONTROL	10.027
B	0.3 GRAM	10.711
C	0.6 GRAM	12.224

Table-3.10: Mild steel coupon weight after 12 days in 0.5 M HCI at 30°C containing 0.3 and 0.6g *lasientheraafrican* extract

Sample Mild steel	Inhibitor used	Weight
A	CONTROL	10.017
B	0.3 GRAM	10.708
C	0.6 GRAM	12.220

RESULTS AND DISCUSSIONS

4.1 RESULTS

The effect *of Lasienthera Africanum* extract on the corrosion of aluminum and mild steel in 0.5M HC1 was studied under room temperature i.e 30°C. The data obtained for the corrosion behavior of the aluminum and mild steel coupons in the presence and absence of the inhibitor is given in the tables below. Data Collected in the Presence and Absence of Lasienthera Africanumm (LA) Inhibitor on Mild Steel.

Table-4.1: weight loss measurement, corrosion rate and inhibiting efficiency on mild steel in 0.5M HC1 at 30°Ccontaining 0.3 and 0.6g *Lasientheraafricanum* extract

SPECIMEN	INITIAL WEIGHT W1	FINAL WEIGHT Wr	WEIGHT LOSS ΔW(g)	CORROSION RATE (mm?yr)	INHIBITION EFFICIENCY (%)
DAY 2					
A	10.316	10.200	0.1616	5.188 X 10^{-3}	
B	12.881	12.799	.082	3.700 x 10^{-3}	27.7
C	12.470	12.467	0.003	1.3 x 10^{-4}	97.34
DAY 4					
A	10.200	10.130	0.07	2.892 x 10^{-3}	
B	12.799	12.764	0.035	1.446 x 10^{-3}	50
C	12.467	12.312	0.155	1.07 x 10^{-3}	63

DAY 6					
A	10.130	10.093	0.037	1.68 x 10^{-3}	
B	12.764	12.747	0.017	7.717 x 10^{-3}	*57.32*
C	12.312	12.300	0.012	5.52 x 10^{-3}	67.14
DAY 8					
A	10.093	10.071	0.022	1.00 x 10^{-3}	
B	12.474	12.734	0.013	5.9 x 10^{-4}	41
C	12.300	12.250	0.05	1.304 x 10^{-4}	76.96
DAY 10					
A	10.071	10.027	0.044	2.019 x 10^{-3}	
B	12.734	12.711	0.023	1.047 x $10^{-4,}$	94.81
C	12.250	12.224	0.0026	1.0216 x 10^{-4}	94.93
DAY 12					
A	10.027	10.014	0.01	4.60 x 10^{-3}	
B	12.711	12.708	0.003	1.3660 x 10^{-4}	70.30
C	12.224	12.220	0.004	1.271 x 10^{-4}	72.3
DAY 14					
A	10.014	10.007	0.01	4.60 x 10^{-4}	
B	12.708	12.702	0.006	2.736 x 10^{-4}	40.52
C	12.220	12.214	0.006	2.706 x 10^{-4}	41.17
DAY 16					
A	10.007	9.970	0.037	1.708 x 10^{-4}	
B	12.702	12.674 —	0.0028	1.278 x 10^{-4}	25.13
C	12.214	12.199	0.0015	6.95 x 10^{-4}	59.30
DAY 18					
A	9.970	9.957	0.013	6.00 x 10^{-4}	
B	12.674	12.668	0.006	2.740 x 10^{-4}	54.33
C	12.199	12.194	0.005	2.339 x10^{-4}	61.01

Specimen A – CONTROL
Specimen B – 0.3 GRAM LA
Specimen C-0.8 GRAM LA

Data Collected in the Presence and Absence of Lasienthera Africanumm (LA) Inhibitor on Aluminum

Table-4.2: Weight loss measurement, corrosion rate and inhibiting efficiency on aluminum in 0.5M HC1 at 30°Ccontaining 0.3 and 0.6g *Lasientheraafricanum* extract

SPECIMEN	**INITIAL WEIGHT W1**	**FINAL WEIGHT Wf**	**WEIGHT LOSS AW(g)**	**CORROSION INHIBITION RATE EFFICIENCY (mmlyr.) *(%)***	
DAY2					
A	1.769	1.740	0.029	5.26 x	
B	1.750	1.741	0.009	1.485 x 10^{-3}	71.76
C	1.760	1.758	0.002	1.390 *x* 10^{-4}	73.58
DAY4					
A	1.740	1.725	0.015	2.76 x 10^{-3}	
B	1.741	1.736	0.005	8.449 x 10^{-4}	69.38
C	1.758	*1.755*	0.002	4.352 x 10^{-4}	84.23
DAY6					
A	1.725	1.714	0.011	2.091 x 10^{-3}	
B	1.736	1.730	0.006	1.106 x 10^{-3}	47.10
C	1.758	1.755	0.003	4.185 x 10^{-4}	79.90
DAY8					
A	1.714	1.697	0.017	3.191 x 10^{-3}	
B	1.730	1.715	0.015	2.50 x 10^{-3}	21.65
C	1.755	1.747	0.008	1.116 x 10^{-3}	65.0

DAY 10					
A	1.697	1.603	0.094	0.01821	
B	1.715	1.769	0.025	0.01597	12.30
C	1.747	1.730	0.017	2.393×10^{-3}	86.85
DAY 12					
A	1.603	1.570	0.033	6.647×10^{-3}	
B	1.769	1.667	0.023	3.930×10^{-4}	94.0
C	1.730	1.728	0.0002	2.829×10^{-5}	*99.56*
DAY 14					
A	1.570	1.535	*0.035*	7.193×10^{-3}	
B	1.667	1.642	*0.025*	4.60×10^{-3}	38.04
C	1.728	1.720	0.008	1.137×10^{-3}	84.1
DAY 16					
	1.535	1.500	*0.035*	7.39×10^{-3}	
	1.642	1.615	0.027	4.774×10^{-3}	*35.45*
	1.720	1.704	0.016	2.28×10^{-3}	69.09
DAY 18					
	1.500	1.477	0.023	4.926×10^{-3}	
	1.615	1.600	0.015	2.699×10^{-3}	44.80
	1.704	1.699	0.005	7.207×10^{-4}	85.36

Specimen A-CONTROL
Specimen B-0.3 GRAM LA
Specimen C-0.8 GRAM LA

4.3 DISCUSSION

4.2.1 Corrosion Rate and Inhibitor Efficiency

In order to properly situate the interpretation for corrosion rate vs time graph considering that the chart on the graphs are not so distinctly separated to delineate performance. This was done by averaging the corrosion rite values for each of the inhibitor concentration over the 18 days period. These values were then compared to the control experiment to rank inhibitor performance. Based on this criterion it was possible to compare corrosion rate data with IE values since an indirect relationship exists between them. Table 4.1 and 4.2 shows the ranking of the performance of the inhibitor concentration in inhibiting corrosion. By comparing the information in the Tables 4.1 - 4.2 to the IE graph (Figures 4.3 - 4.4) we see that an indirect relationship exists. The inhibitor concentration with the highest corrosion rate had the lowest inhibition efficiency (IE), while the inhibitor concentration with lowest corrosion rate had the highest inhibition efficiency (IE).

4.3 FINDINGS

Comparatively, the green inhibitor lasienthera africanum has more inhibition efficiency on aluminum with 91.29% shown on fig. 4.3 than mild steel with 70.35. It was also observed in the course of this experiment that the more concentration of this green inhibitor lasienthera africanum used on both aluminum and mild steel, the slower the corrosion rate and then the higher the inhibition efficiency on these metals The rate of corrosion of the aluminum and mild steel in HC1 environmental conditions is a function of the concentration *of Lasienthera Africanum* extract. The corrosion rates drastically decreased with increase in concentration of the extracts in comparison to the blank. The 0.6g extract have the lowest corrosion rate, which depict that the inhibitive action of the extract is concentration dependent. The average Inhibitor efficiency in aluminum for 0.3g and 0.6g concentration of green inhibitor is observed to be 48% and 91.29% while that of mild steel is 51.23% and 70.3 5% for 0.3g and 0.6g of lasienthera africanum respectively. Comparatively ,aluminum has shown highest inhibition efficiency for this type of inhibitor used for this study.

5. CONCLUSION

LA has been demonstrated to be an effective corrosion inhibitor for O.5M HC1 environments and the corrosion resistance and inhibitor efficiency of aluminum and mild steel increased with addition of *LA* as inhibitor. Inhibition efficiency as high as 97.34 and *99.56%* in O.5M HCL both at mild steel and aluminum respectively were observed. The rate of corrosion of the aluminum and mild steel in HC1 environmental conditions is a function of the concentration of *LA* extract. The corrosion rates drastically decreased with increase in concentration of the extracts in comparison to the blank. The O.6g extract have the lowest corrosion rate, which depict that the inhibitive action of the extract is concentration dependent. From the results obtained, it can be suggested that *LA* extract can be tried as an inhibitor for other metals in various corrosive conditions.

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